"It seems to me that many people need to make themselves seem important. That can make it difficult for historians to sort out where the truth lies - where credit belongs. In me you have someone who cares little about credit, and in fact I'm often given more credit than I feel I deserve."

Severo M Ornstein - Computer Scientist at BBN

Interviewed on December 10th 2003 in Palo Alto (CA)

Born on October 13, 1930 in Pennsylvania, Philadelphia. Severo Ornstein studied at Harvard University (1951 A.B. Cum Laude). He did graduate work in geophysics and mathematics at U.C. Berkeley and Harvard University (1952).

1953-1955: Geophysical researcher at Gulf R&D Co. Pittsburg, Pa, analyzing and interpreting seismic data for oil exploration.

1955-1963: MIT's Lincoln Laboratory, work on design of the SAGE air-defense system, simulation studies, hardware design

1963-1967: MIT and Washington University - worked on design, programming, production, and utilization of the LINC computer for biomedical research

1967-1976: Bolt, Beranek & Newman one of ARPAnet system designers. Designed all initial hardware and later terminal handling hardware. Served as assistant to the director of the ARPAnet Project. Teaching computer design and programming courses at Harvard.

1976-1983: Xerox PARC Computer Science Laboratory - work on early laser printer hardware; associate director Dorado project (early high-speed personal computer); Mockingbird music editing system; managerial tasks

1981-1985 Founder and chairman of Computer Professionals for Social Responsibility (CPSR).

www.hardvard.edu
www.mit.edu
www.bbn.com
www.parc.org
www.CPSR.org

Do you remember when you had your first contact with a computer?

Yes, I remember it very clearly. It was in 1953, and had to do with a climbing rope. I am a mountain climber and I was working as a geophysicist for a Gulf Oil

company in Pittsburgh, Pennsylvania. One morning on the way to work, I noticed a climbing rope in the back of a car in the parking lot. I asked the guard whose car it was and looked up the owner, who is a friend of mine to this day. We were doing routine interpretation of seismic data and it had seemed to me that much of the work was routine - something that a machine could do. My new friend had worked on this very problem at MIT on the Whirlwind computer and shortly he began to explain the workings of the machine to me. One thing led to another and shortly I found myself writing short programs for the Whirlwind computer. These were early days and programming was done in a primitive assembly language.

What was your first contact/experience with Internet or ARPANET?

My first involvement with what became the Internet was the RFP[1] that came to BBN from ARPA. In 1967 I left Washington University and went to work for my old Lincoln Lab. friend, Frank Heart at BBN. One night in early 1969, he handed me the RFP and said "why don't you look this over, see what you think of it". I took it home and when I came back, I said "well, it looks straightforward enough -we could build it all right - but I can't imagine why anybody would want such a thing!"

That's funny in retrospect, but from the perspective of an engineer, focused on the tremendous diversity of the then existing computers, getting them to work productively together seemed an insurmountable task. I wasn't aware of the vision that people like Licklider, Taylor and a few others had, and frankly, had I been, I would have dismissed it as dreaming. And indeed it turned out to be extremely difficult and took nearly twenty years, the hard work of countless people developing protocols, and the development and proliferation of computers before the dream could begin to be realized. In the intervening years the nature of computers, computer usage, and inter-computer communication all changed dramatically from the initial justification which had to do with connecting all of the ARPA sites, so that they could share resources, programs, and so forth.

In your opinion, what are the key characteristics of Internet?

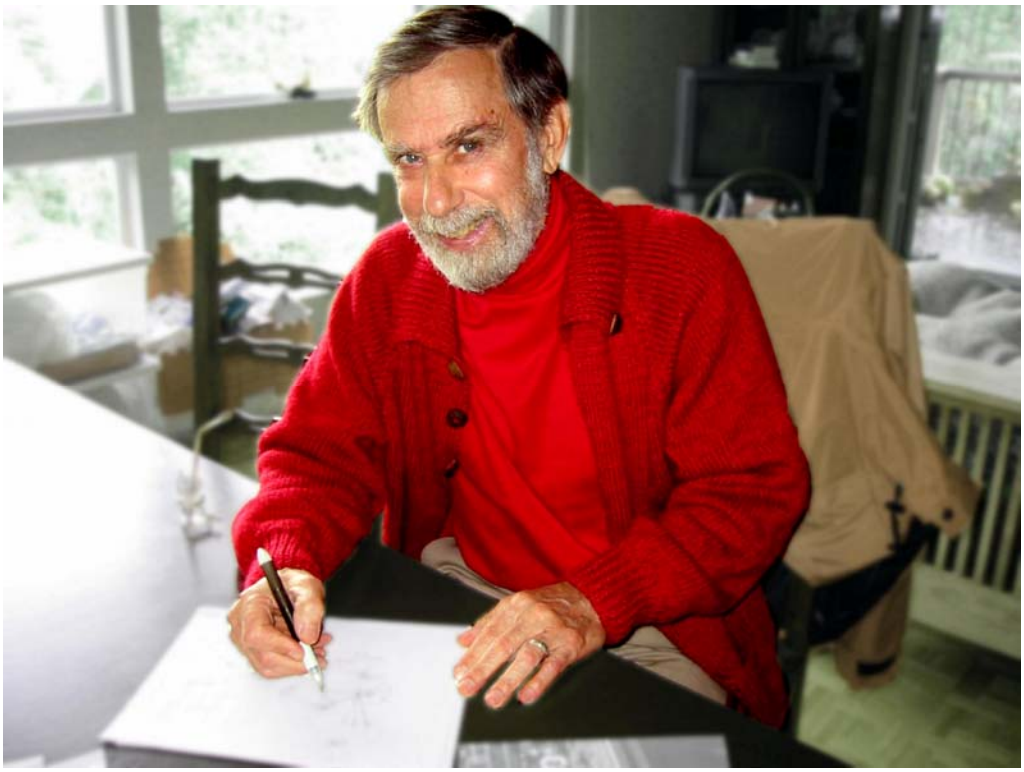
From my perspective the Internet's most important impact has been its role in serving as a tool for democracy. An early and clear example of this arose during Bill Clinton's presidency. The public was impatient with the Republican movement to impeach the president for his affair with Monica. This gave rise to an Internet-based movement and an organization called *Move On* that remains a powerful political force today. The net has since provided an alternative means for all sorts of political discussion and activity by ordinary citizens who are otherwise often cut off from democratic processes by centralized information sources such as television. So for me, the most important

[1] RFP: Request For Proposals. A very common way to describe a public administration needs in order to obtain commercial proposals.

characteristic is the ability to provide a way for ordinary people to be involved in vital social and political matters.

What do you consider the most important milestones in the development of the network?

- 1970-71 The building of the subnet, which was the initial backbone net
- 1974 The development of E-mail
- 1991 The development of the World Wide Web



How did you contribute to the development of the Internet?

The building of the subnet and making it work. It was a nice isolated task that I knew we could handle. It was quite straightforward engineering. The RFP was very detailed; many things were spelled out in detail. Nonetheless, in our proposal to ARPA we made a few minor changes which we felt were improvements.

BBN was a small company and the RFP (Request For Proposals) was the kind that is usually won by big companies. So we knew that our proposal had to be exceptional - substantially better than everyone else's in order for us to win. We put a lot of effort into the proposal - we actually designed the complete system in great detail. But all that most basic layer of the system did was to pass packets reliably between hosts. Figuring out how to build the overlying sets of layers, whereby the hosts could talk to one another using that first layer was the tricky part, and it took several years.

I have watched with wonder as things have evolved since then. I simply helped to build that first part, that's all. After that, I had nothing to do with the Internet - except, of course, as a user.

Who are some key people in the development of Internet, leaders or trendsetters?

I don't know about leaders and trendsetters, but there were, of course, several key, well-known figures, such as **J.C.R. Licklider** - visionaries who looked forward to the kind of world we are coming to live in. Also of course there is **Tim Berners Lee** who helped to bring it about by creating the World Wide Web. I can only tell you about some of the key people with whom I worked directly who were responsible for the early network and were (and are) friends and associates:

Larry Roberts is one of the few people able to manage a project of this size and keep track of all the details himself. If I must point to one person who made the initial net happen, it would be Larry. Of course he was pushed by the likes of **Bob Taylor** who had brought him to ARPA with the specific intention of getting him to manage the project - something Bob, despite superb instincts, didn't have the technical capability to do.

Wes Clark contributed the key notion of separating out the subnet management (packet handling, flow control, routing, error handling, etc.) into a small computer (originally called an IMP), separate from the host computer, at each site. The original idea had been to connect hosts directly, which would have required every host to solve these problems in a compatible fashion - a true nightmare. Wes suggested instead building a subnet consisting of a small computer attached to each host computer and letting these small computers take care of the network affairs. That way, each host computer would need to communicate only with its IMP. Of course ultimately the host computers did have to figure out how to talk to one another, but only at the higher levels. The IMP partitioned the problem neatly.

Frank Heart was the leader of the Arpanet group at BBN that constructed and ran the subnet. He provided both technical and managerial control of the project.

Will Crowther, was a superb machine language programmer. He worked closely with **David Walden** and **Bernie Cosell.** All were extremely bright engineers who had a major hand in the subnet software design. Will later built the first computer game that became the predecessor of the Dungeon and Dragons type of game.

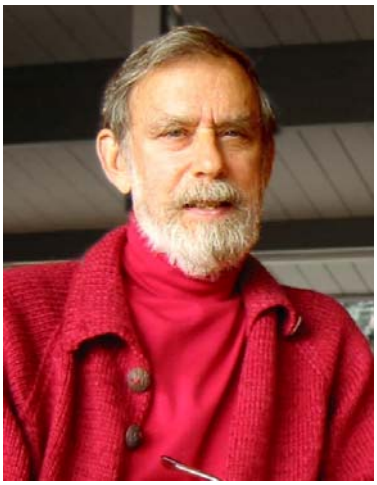
Bob Kahn had been a specialist in signal processing at MIT and was responsible for the error handling algorithm that we then built into the IMP hardware. Bob and I worked closely together, initially figuring out some of the broad system design problems. As he wanted to learn more about hardware, I explained it to him as the design progressed.

Ray Tomlinson noted that the Tenex systems at many ARPA research sites already embodied the ability for users at the local site to communicate with one another using their time-sharing terminals. He saw that with modest effort this capability could be extended to allow workers at remote sites to communicate with one another. He needed, of course, to specify which user at which remote site the message was going to and he chose the designation "Johndoe@sitename." Thus was born the designation system that has become universal today and with it fame for "inventing the @ symbol." Ray did far more clever things than that, but nothing that earned him nearly the notoriety!

Norm Abramson built the radio-based ALOHA network system in Hawaii for communicating between campuses on different islands. He invented the collision scheme which was later adopted and modified by **Bob Metcalfe** at Xerox PARC to create the Ethernet for Local Area Networks.

There were other figures whom I knew less well and these include **Vint Cerf**, and **Steve Crocker** who worked on the host-to-host protocols. Also **Leonard Kleinrock**, who was concerned with traffic flow in the net.

Can you describe two anecdotal situations?



People who had no connection to a particular host wanted to be able to access the net directly from a terminal, not through one of the hosts. So, we built a Terminal IMP (called a TIP) that embodied what we called a "mini-host." It provided the very basic parts of the host protocol that then allowed the terminal user to gain access to any host on the network without initially going through a given host. Users then began to view the phone lines that connected their terminal to the TIP as part of the network and when the phone line failed, they complained that the network was failing. So BBN took on the responsibility for periodically testing the terminal ports and lines.

All of these lines were phone lines with modems and phone numbers that were regularly tested by an automatic dialer, to verify that the lines were working. One day the technicians at the Network Control Center (NCC), seeing that one line was having trouble, listened as it was dialed. They heard the familiar "tweet" sound of the modem trying to connect, and suddenly there was a voice on the other end of the line saying "So it's YOU again!!!" and the receiver was slammed down. It turned out that a wrong number had been entered into the dialer so it was actually dialing some poor individual's telephone.

Because BBN was a member of the network, it had an IMP which served its host computer and through which it controlled the network. One day, for a reason I no longer remember, we needed to put a small jumper wire on a pair of pins at the bottom of its electronics panel wiring. As it was running in the

network at the time, we didn't want to turn it off to install the jumper - a delicate operation as it was necessary to avoid touching any of the many nearby pins. So, everybody gathered around and because I was in charge of hardware, I got down on my hands and knees and prepared to install it. I inserted the jumper ever so carefully, but nonetheless touched a nearby pin, which immediately shut down the machine. Bells rang everywhere and the technicians who were responsible for keeping the network up rushed in, kicked us out of the way, and quickly put it all back up again. Whereupon we realized that we had failed to put the jumper while the machine was down. At that point Ben Barker, a former student of mine who had a terribly shaky hand stepped forward and said "Here, let me." Having failed once I passed him the jumper and then, dumbfounded, watched Ben's hand momentarily stopped shaking as he shoved it into place, whereupon his hand immediately resumed its tremor. I couldn't believe it.

What do you think about the future of Internet?

My interest in it is really in the political arena. I worry that the Internet will be dominated by commercial interests, and the kind of use that I have hoped for, enhancing our democracy, will be suppressed.

Do you see any technological trends?

I suspect that speeds will continue to increase, because once you get high enough speed, you can do things that you couldn't even think about doing at a lower speed. There's also a trend towards artificial intelligence, but I continue to be an AI skeptic. I believe that we acquire true intelligence through individual experience and development - a process of evolution that I suspect can't be shortcut by clever planning. What we've seen so far is not the sort of artificial intelligence that people imagined - something approaching the broad spectrum of human intellect.

ADDITIONAL READING
PAPERS & BOOKS MENTIONED / RECOMMENDED

- *Where Wizards Stay Up Late.* 1996 by Katie Hafner and Matthew Lyon. New York Touchstone Simon & Schuster. ISBN 0-684-81201-0
- *Computing In the Middle Ages. A View from the Trenches 1955-1983.* Editor: Lightning Source Inc. Severo M. Ornstein ISBN: 1403315175
- *The Dream Machine JCR Licklider and the Revolution that made Computing Personal.* 2001 Mitchell Waldrop. Penguin Books. ISBN 0-670-89976-3